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(54) **MULTI-CORE CABLE**  
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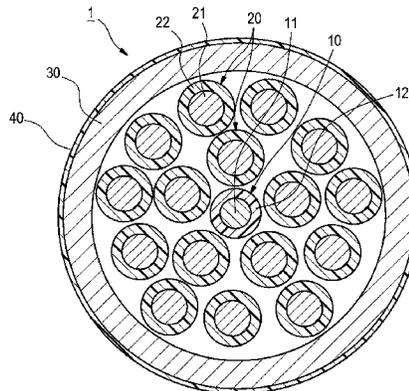
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(57) **ABSTRACT**

(58) **Field of Classification Search**  
CPC ..... B21B 1/46; C22C 21/00; C22C 21/06; C22C 21/10; H01B 7/00; H01B 7/20; H01B 11/1895; H01B 11/1808; H01B 11/18; H01B 11/02; H01B 7/048; H01B 7/04; G02B 6/44; A61B 1/00114; H01R 13/50; H02P 25/16; H05K 9/00

One embodiment provides a multi-core cable including: at least one ground wire which is arranged in a center or its vicinity in a cross section perpendicular to a length direction of the cable; plural insulated wires arranged in a periphery of the ground wire; an overall shield layer which covers a periphery of the insulated wires; and a sheath which covers a periphery of the overall shield layer.

**7 Claims, 3 Drawing Sheets**



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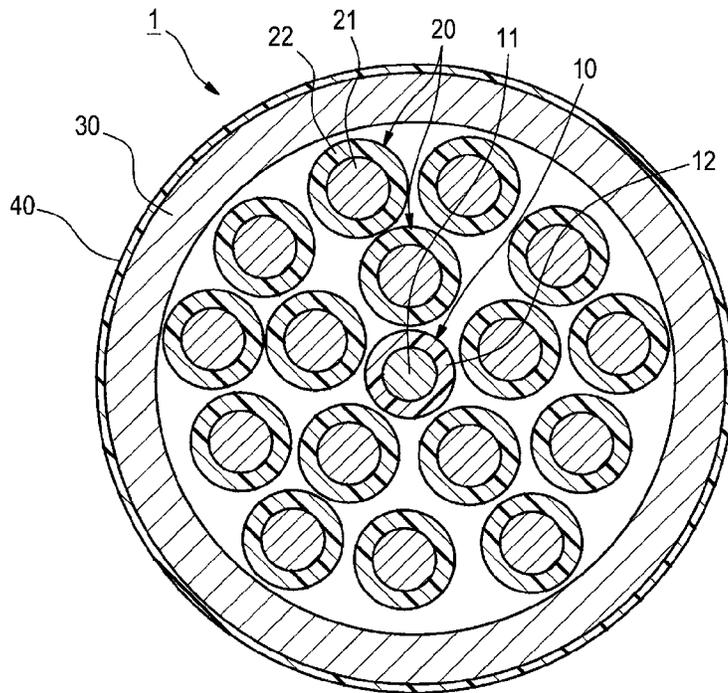
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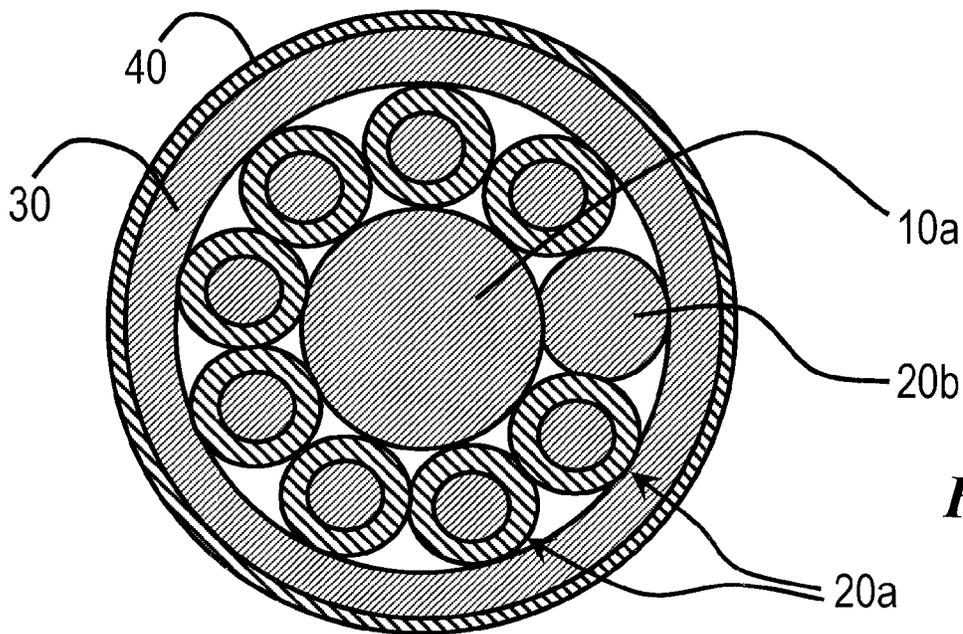
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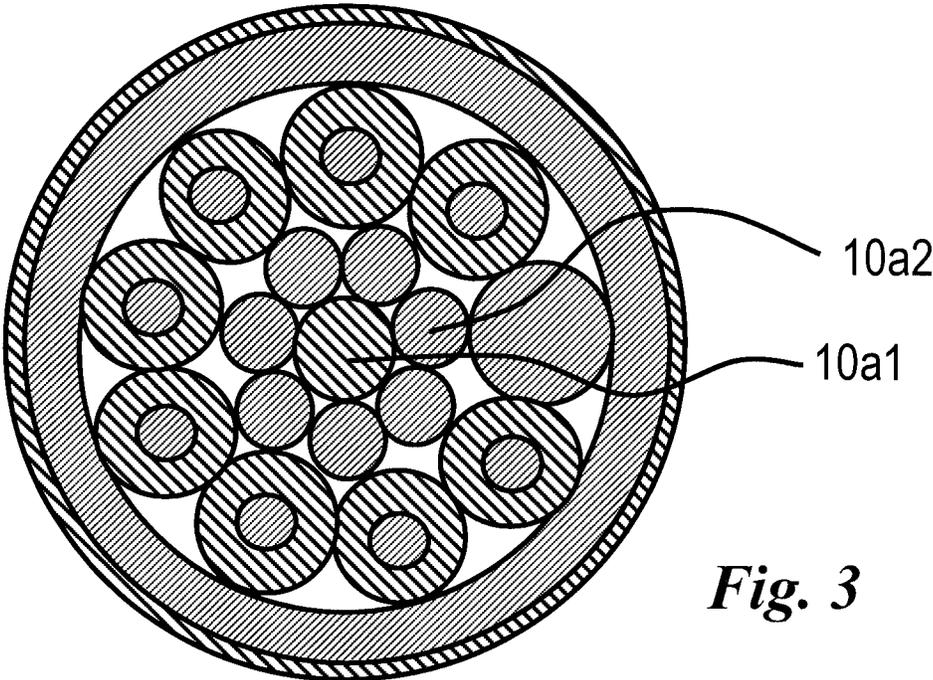
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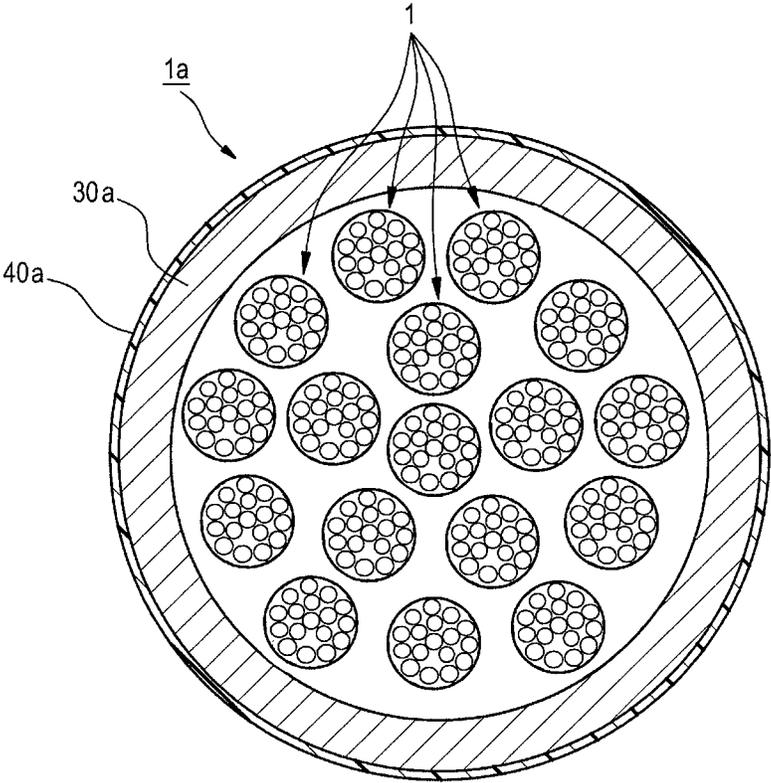
*Fig. 1*



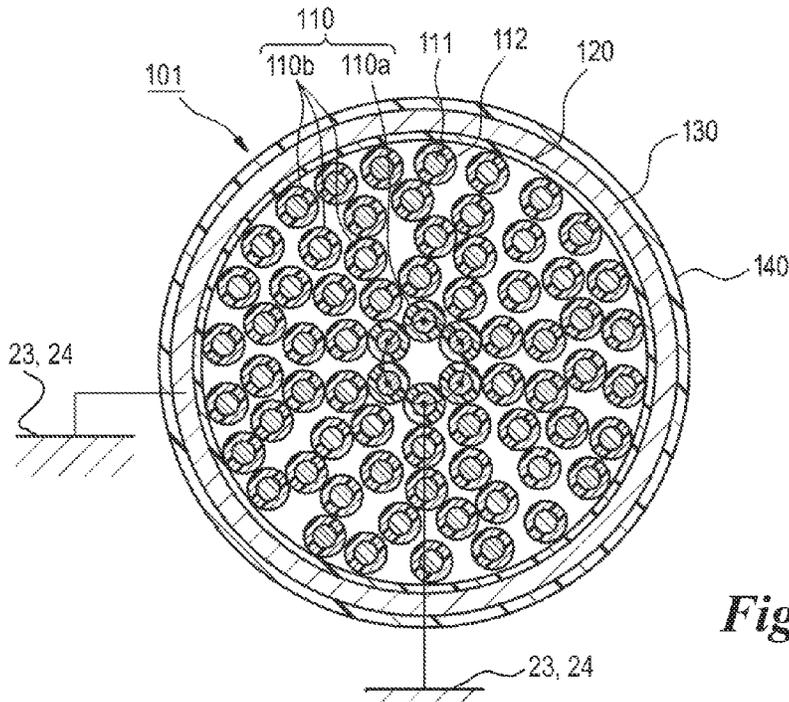
*Fig. 2*



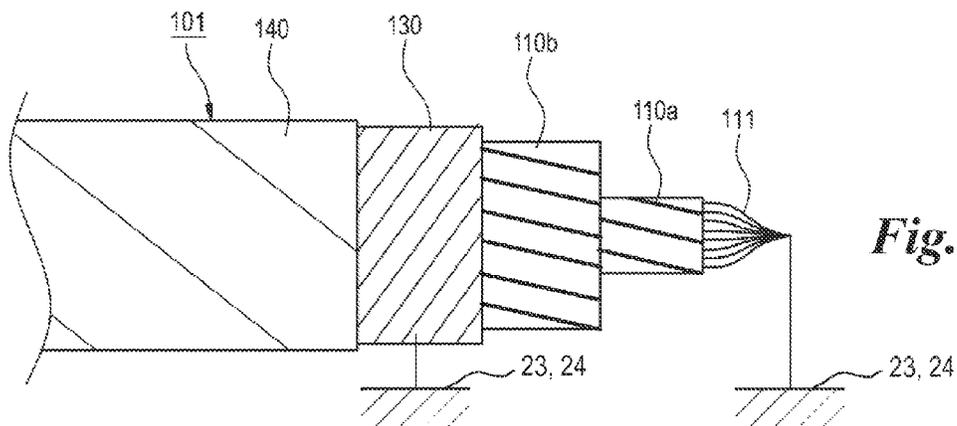
*Fig. 3*



*Fig. 4*



*Fig. 5*



*Fig. 6*

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**MULTI-CORE CABLE****CROSS-REFERENCE TO RELATED APPLICATION(S)**

This application claims priorities from Japanese Patent Application No. 2012-142770 filed on Jun. 26, 2012 and from Japanese Patent Application No. 2012-145002 filed on Jun. 28, 2012, the entire contents of which are incorporated herein by reference.

**FIELD**

The present invention relates to a multi-core cable having a ground wire and plural insulated wires.

**BACKGROUND**

For high-frequency transmission, a multi-core cable in which plural coaxial cables are collected inside a sheath member having flexibility is known (for example, see JP-2001-023456-A).

Such multi-core cable may be used in medical devices such as a catheter, an endoscope or a probe cable for ultrasonograph, and thus, further reduction in diameter thereof is desired in order to improve workability or handleability of the cable to thereby reduce a stress for a patient to be treated with the endoscope etc.

**SUMMARY**

An object of the invention is to provide a multi-core cable having good electrical characteristics while enabling a reduction in diameter.

One aspect of the invention provides a multi-core cable including:

at least one ground wire which is arranged in a center or its vicinity in a cross section perpendicular to a length direction of the cable;

plural insulated wires arranged in a periphery of the ground wire;

an overall shield layer which covers a periphery of the insulated wires; and

a sheath which covers a periphery of the overall shield layer.

In the multi-core cable,

the ground wire may be arranged in the center in the cross section, and

the overall shield layer and the ground wire may be coaxial.

In the multi-core cable,

the insulated wires may be arranged in plural layers so that each layer is coaxial with the ground wire.

Another aspect of the present invention provides a multi-core cable including:

plural wire units, each wire unit being the above-mentioned multi-core cable;

another overall shield layer which collectively covers a periphery of the plural wire units; and

another sheath which covers a periphery of the another overall shield layer.

In the multi-core cable,

the ground wire may be another insulated wire, and a terminal processing may be performed so as to ground the ground wire and the overall shield layer.

In the multi-core cable,

at least two of the insulated wires as the ground wires may be provided.

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In the multi-core cable,  
the ground wire may be a conductor wire,  
another conductor wire and the insulated wires may be arranged in a layer around the ground wire, and

5 the another conductor wire may electrically connect the ground wire and the overall shield layer.

According to the invention, the ground wire arranged in the center or its vicinity in the cross section of the cable and the overall shield layer are coaxial, thereby providing the multi-core cable having good electrical characteristics in terms of practicality with a reduced diameter.

**BRIEF DESCRIPTION OF DRAWINGS**

15 FIG. 1 cross-sectionally shows a multi-core cable of Embodiment 1.

FIG. 2 shows one example of a multi-core cable of Embodiment 6.

20 FIG. 3 shows another example of a multi-core cable of Embodiment 6.

FIG. 4 cross-sectionally shows a multi-core cable of Embodiment 7.

FIG. 5 cross-sectionally shows a multi-core cable of Embodiment 8.

25 FIG. 6 shows terminal processing of the multi-core cable of Embodiment 8 from side.

**DETAILED DESCRIPTION****Embodiment 1**

A multi-core cable of Embodiment 1 will hereinafter be described with reference to the drawings.

As shown in FIG. 1, a multi-core cable 1 of Embodiment 1 includes a ground wire 10, plural insulated wires 20, an overall shield layer 30 which covers the ground wire 10 and the insulated wires 20, and a sheath 40 which covers the periphery of the overall shield layer.

The ground wire 10 is constructed of a central conductor 11 and an insulating coating 12 which covers the periphery of the central conductor 11. In Embodiment 1, the ground wire 10 uses, for example, an AWG 42 (American Wire Gauge number 42) wire. The central conductor 11 of the ground wire 10 is not necessarily covered with the coating 12. However, when the central conductor 11 is covered with the coating 12, for example, the central conductor of the ground wire 10 and a central conductor 21 of the insulated wire 20 described below can be prevented from being short-circuited due to friction between the ground wire 10 and the peripheral insulated wires 20.

As the central conductor 11 of the ground wire 10, for example, a twisted wire is used. For example, in the case of twisting seven tin-plated annealed copper wires or silver-plated annealed copper wires with a conductor diameter of 0.025 mm, a twisted wire with an outside diameter of 0.075 mm is obtained.

As a material of the coating 12 of the ground wire 10, it is preferable to use a fluorine resin such as a perfluoroalkoxy resin (PFA) with good heat resistance, chemical resistance, non-adhesion, self-lubricity, etc. The coating 12 is formed by extruding this fluorine resin or winding a fluorine resin tape, and an outside diameter of the coating 12 is, for example, 0.20 mm.

In this multi-core cable 1, the ground wire 10 is arranged in the center in a cross section (cross section shown in FIG. 1) perpendicular to a length direction of the cable. And, the plural (16 herein) insulated wires 20 are arranged around this

ground wire **10**. An intervening substance such as aramid fiber or spun rayon yarn may be provided in a gap between the ground wire **10** and the insulated wires **20**.

Each of the insulated wires **20** is constructed of a central conductor **21** and an insulating coating **22** which covers the periphery of the central conductor **21**. In Embodiment 1, the central conductor **21** of the insulated wire **20** is the AWG 42 (American Wire Gauge number 42) wire.

Like the central conductor **11** of the ground wire **10**, as the central conductor **21** of the insulated wire **20**, for example, a twisted wire with an outside diameter of 0.075 mm obtained by twisting seven silver-plated annealed copper wires with a conductor diameter of 0.025 mm is used.

As a material of the coating **22** of the insulated wire **20**, it is preferable to use a material similar to that of the coating **12** of the ground wire **10**. An outside diameter of the coating **22** is, for example, 0.26 mm slightly larger than the outside diameter of the coating **12**.

As shown in FIG. 1, for example, the five insulated wires **20** may be arranged around the ground wire **10** as a first layer and the eleven insulated wires **20** are arranged around the first layer as a second layer. That is, the insulated wires **20** may be arranged in plural layers so that each of the first and second layers are coaxial with the ground wire **10**.

The insulated wires **20** may be twisted respectively for the first layer and the second layer. Or, the ground wire **10** and all the insulated wires **20** may be collectively twisted so as to maintain a relative positional relationship between the insulated wires **20** and the ground wire **10**.

The periphery of the ground wire **10** and the plural insulated wires **20** arranged in this manner is covered with the overall shield layer **30**. The overall shield layer **30** is formed by spirally winding, for example, plural (79 herein) tin-plated annealed copper wires with a conductor diameter of 0.05 mm on the periphery of the ground wire **10** and the insulated wires **20**, and an outside diameter of the overall shield layer **30** is, for example, 1.32 mm. The overall shield layer **30** may be constructed by braiding small-diameter metal wires.

The outer periphery of this overall shield layer **30** is further covered with the sheath **40**. The sheath **40** is formed by wrapping, for example, a resin tape made of polyethylene terephthalate (PET) with a thickness of 4  $\mu$ m on the periphery of the overall shield layer **30**.

In the multi-core cable **1** of Embodiment 1 including one AWG 42 ground wire **10** and 16 AWG 42 insulated wires **20**, an outside diameter of the sheath **40** is, for example, 1.34 mm.

The sheath **40** may be obtained by extruding and coating polyvinyl chloride (PVC), polyolefin or fluorine resin, instead of using a resin tape.

In Embodiment 1, the ground wire **10** arranged in the center in a cross section of the cable is coaxial with the overall shield layer **30** which covers the periphery of the insulated wires **20**. Consequently, the multi-core cable **1** itself functions as a coaxial cable.

In addition, both ends of the ground wire **10** and both ends of the overall shield layer **30** are respectively grounded to the outside.

As described above, an insulated conductive wire is constructed of a central conductor and an insulating coating which covers the periphery of the central conductor. On the other hand, a coaxial wire further includes an external conductor which covers the periphery of the insulating coating and a protective coating which covers the external conductor, in addition to a configuration (the central conductor and the inside insulating coating) of the insulated conductive wire. Consequently, in the case of using a coaxial wire as each core wire like a conventional multi-core cable, an outside diameter

of each core wire (coaxial wire) becomes larger than the case of using an insulated conductor as each core wire. Accordingly, an outside diameter of the multi-core cable also becomes larger.

An outside diameter of the multi-core cable **1** of Embodiment 1 including 16 AWG 42 insulated wires **20** is, for example, 1.34 mm. On the other hand, an outside diameter of an outermost sheath of the conventional multi-core cable including the same number (16) of AWG 42 coaxial wires is, for example, 1.55 mm.

The multi-core cable **1** of Embodiment 1 is smaller in diameter than the conventional multi-core cable using the coaxial wire as each core wire. As a result, handleability of the cable is improved and also, workability in the case of connecting the terminal of the cable to a wiring substrate of a medical device such as an ultrasonograph is improved. An example of a ground terminal **23** of the wiring substrate is shown in FIGS. 5 and 6. Further, a stress for a patient to be treated with an endoscope can be reduced.

Also, the multi-core cable **1** of Embodiment 1 has a pseudo coaxial structure by respectively grounding the ground wire **10** and the overall shield layer **30** which are coaxial, thereby providing good electrical characteristics for practical use in terms of characteristic impedance, capacitance, shielding properties, etc.

Although one embodiment is described above, the invention is not limited thereto, and other configurations can be adopted as necessary.

For example, the numbers of ground wires **10** and insulated wires **20** in the multi-core cable **1** are not limited to those of Embodiment 1. Also, in Embodiment 1, the outside diameter of the ground wire **10** is set smaller than the outside diameter of the insulated wire **20**, but instead of this, the outside diameter of the ground wire **10** may be set substantially equally to the outside diameter of the insulated wire **20**, or the outside diameter of the ground wire **10** may be set larger than the outside diameter of the insulated wire **20**.

Although the periphery of the central conductor **11** of the ground wire **10** is covered with the coating **12** in Embodiment 1, the coating **12** may be omitted since the ground wire **10** is merely to be grounded.

In Embodiment 1, as the coating **12** of the ground wire **10** and the coating **22** of the insulated wire **20**, the fluorine resin such as the perfluoroalkoxy resin (PFA) is used, but the coating **12**, **22** may be a foam, and in order to better improve electrical characteristics, for example, a metal tape may be wound on a surface of the coating **12**, **22**, or the surface may be plated with metal. The insulated wires **20** of an outermost layers may be wrapped with a resin tape such as a PET tape, inside the overall shield layer **30**.

#### Embodiment 2

In Embodiment 1, the twisted wire obtained by twisting seven silver-plated annealed copper wires is used as the central conductor **11** of the ground wire **10** and the central conductor **21** of the insulated wire **20**, but instead of this, for example, a copper alloy wire of a single wire with an outside diameter of 0.064 mm may be used. Similarly in this case, when setting an outside diameter of a coating **12** of a ground wire **10** at 0.20 mm and setting an outside diameter of a coating **22** of an insulated wire **20** at 0.26 mm, an outside diameter of an outermost sheath **40** is, for example, 1.34 mm, and a multi-core cable with a diameter smaller than that of a conventional multi-core cable using a coaxial wire as each core wire can be obtained.

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## Embodiment 3

In Embodiment 1 and Embodiment 2, the AWG 42 wire is used as the ground wire **10** and the insulated wire **20**, but instead of this, an AWG 40 wire may be used.

In a multi-core cable of Embodiment 3, one AWG 40 ground wire **10** is arranged in the center, and five AWG 40 insulated wires **20** are arranged in the periphery of the ground wire **10** as a first layer, and eleven AWG 40 insulated wires **20** are further arranged in the periphery of the first layer as a second layer.

In Embodiment 3, as a central conductor **11** of the ground wire **10**, for example, a twisted wire with an outside diameter of 0.09 mm obtained by twisting seven tin-plated copper alloy wires with a conductor diameter of 0.03 mm is used. An outside diameter of a coating **12** of the ground wire **10** is, for example, 0.25 mm.

As a central conductor **21** of the insulated wire **20**, for example, a twisted wire with an outside diameter of 0.09 mm obtained by twisting seven tin-plated copper alloy wires with a conductor diameter of 0.03 mm is used. An outside diameter of a coating **22** of the insulated wire **20** is, for example, 0.31 mm.

An overall shield layer **30** may be formed by spirally winding, for example, plural (about 94 herein) tin-plated annealed copper wires with a conductor diameter of 0.05 mm on the periphery of the ground wire **10** and the insulated wires **20** and in that case, an outside diameter of the overall shield layer **30** is, for example, 1.55 mm.

Also, an outside diameter of a sheath **40** formed by a resin tape made of polyethylene terephthalate (PET) with a thickness of 4  $\mu\text{m}$  is, for example, 1.57 mm.

On the other hand, an outside diameter of an outermost sheath of a conventional multi-core cable collecting the same number (16) of AWG 40 coaxial wires as the number of insulated wires **20** included in the multi-core cable of Embodiment 3 is, for example, 1.83 mm.

Consequently, the multi-core cable of Embodiment 3 using the AWG 40 insulated wires is also smaller in diameter than the conventional multi-core cable formed by collecting plural AWG 40 coaxial wires, and is suitable as the multi-core cable used in a medical device etc.

## Embodiment 4

In Embodiment 3, the twisted wire obtained by twisting seven tin-plated copper alloy wires is used as the central conductor **11** of the ground wire **10** and the central conductor **21** of the insulated wire **20**, but instead of this, for example, a copper alloy wire of a single wire with an outside diameter of 0.08 mm may be used. In this case, similarly to Embodiment 3, when setting an outside diameter of a coating **12** of a ground wire **10** at 0.25 mm and setting an outside diameter of a coating **22** of an insulated wire **20** at 0.31 mm, an outside diameter of an outermost sheath **40** is, for example, 1.57 mm, and a multi-core cable with a diameter smaller than that of a conventional multi-core cable using a coaxial wire as each core wire can be obtained.

## Embodiment 5

In Embodiment 1 and Embodiment 2, the AWG 42 wire is used as the ground wire **10** and the insulated wire **20**, but instead of this, an AWG 32 wire covered with PFA may be used as a ground wire **10**, and eight AWG 40 insulated wires **20** may be arranged in the periphery of the ground wire **10**. In this case, an overall shield layer **30** is formed by spirally

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winding a tin-plated copper alloy wire, and a sheath **40** is formed by wrapping a resin tape made of polyester on the periphery of the overall shield layer **30**.

As a result of measuring electrical characteristics of a multi-core cable **1** in Embodiment 5, characteristic impedance was  $94\Omega$  at a frequency of 10 MHz and capacitance was 64 pF/m. Also, a signal attenuation rate was 0.383 dB/m at the frequency of 10 MHz. These characteristics are sufficient practically as a coaxial cable of this size.

## Comparative Example

As Comparative Example, a multi-core cable having an outside diameter substantially equal to that of the multi-core cable **1** of Embodiment 5 was manufactured using a coaxial wire. Assuming that outside diameters are the same, a central conductor of a coaxial wire is smaller than a central conductor of an insulated wire. Thus, the central conductor of the coaxial wire in Comparative Example is smaller than that of the central conductor of the ground wire **10** or the insulated wire **20** in Embodiment 5. As a result, a measured signal attenuation rate in the multi-core cable of Comparative Example was 0.470 dB/m which is higher than that in the multi-core cable **1** of Embodiment 5.

Conversely, according to Embodiment 5, the multi-core cable **1** having good electrical characteristics (low signal attenuation rate) can be obtained.

## Embodiment 6

As a ground wire, a conductor wire having no cover may be used, and at least one conductor wire may be included in a layer of plural insulated wires arranged around the ground wire, so that the ground wire is electrically connected with an overall shield layer via the conductor wire.

In Embodiment 6, as shown in FIG. 2, a ground wire **10a** consisting of a conductor wire is arranged at a center, and plural insulated wires **20a** are arranged around the ground wire **10a**. Further, a conductor wire **20b** is arranged in the layer of the insulated wires **20a**. Thus, the ground wire **10a** and the overall shield layer **30** are electrically connected with each other through the conductor wire **20b**. A diameter of the conductor wire **20b** may be set to be equal to or slightly larger than a diameter of each of the insulated wires **20a**.

When the overall shield layer **30** is constructed by braided plural metal wires, it is necessary to bundle these plural metal wires for grounding the overall shield layer **30**. Such operation of bundling plural metal wires is troublesome. However, in Embodiment 6, since the ground wire **10a** and the overall shield layer **30** are electrically connected, a ground voltage can be obtained at both of them by grounding only one of them. Thus, when only the ground wire **10a** is grounded, grounding operation (operation of bundling plural metal wires) for the overall shield layer **30** can be avoided. Alternatively, when both of the ground wire **10a** and the overall shield layer **30** are grounded, since they are electrically connected, the ground voltage can be further stabilized.

The ground wire **10a** and/or the conductive wire **20b** may be a twisted wire or a single wire. In the case of using the twisted wire, for example, as shown in FIG. 3, the ground wire **10a** may be constructed by braiding plural conductor wires **10a2** around a non-conductive filler (made of chemical fiber etc.) **10a1** at a center. Although not shown in the figures, the conductor wire **20b** may have the structure similar to the above-illustrated ground wire **10a**.

## Embodiment 7

As shown in FIG. 4, a multi-core cable **1a** may be formed by collecting the multi-core cable **1** of the above-described

embodiments as a wire unit in plurality. The periphery of the plural wire units (multi-core cables **1**) is collectively covered with an overall shield layer **30a**, and the periphery of the overall shield layer **30a** is further covered with a sheath **40a**. Also in this multi-core cable **1a**, an effect similar to that of the above-described embodiments can be obtained.

#### Embodiment 8

A multi-core cable of Embodiment 8 will hereinafter be described with reference to the drawings.

As shown in FIG. 5, a multi-core cable **101** of Embodiment 8 includes plural insulated wires **110**, a wrapping **120** for bundling the plural insulated wires **110**, an overall shield layer **130** which covers the periphery of the wrapping **120**, and a sheath **140** which covers the periphery of the overall shield layer is covered.

Each of the insulated wires **110** is constructed of a central conductor **111** and an insulating coating **112** which covers the periphery of the central conductor **111**. In Embodiment 8, an AWG 47 (American Wire Gauge number 47) wire is used as the insulated wire **110**.

As the central conductor **111** of the insulated wire **110**, for example, a twisted wire with an outside diameter of 0.045 mm obtained by twisting three silver-plated copper alloy wires with a conductor diameter of 0.021 mm is used.

As a material of the coating **112** of the insulated wire **110**, it is preferable to use a fluorine resin such as a perfluoroalkoxy resin (PFA) with good heat resistance, chemical resistance, non-adhesion, self-lubricity, etc. The coating **112** is formed by, for example, extruding this fluorine resin, and a thickness of the coating **112** is, for example, 0.025 mm and an outside diameter of the coating **112** is, for example, 0.090 mm.

As shown in FIG. 5, in the multi-core cable **101** of Embodiment 8, for example, six insulated wires **110a** of the plural (for example, 72 herein) insulated wires **110** are arranged as an internal layer around a center (at a periphery of a center line of the multi-core cable **101**) in a cross section perpendicular to a length direction of the multi-core cable **101**. The other insulated wires **110b** are coaxially arranged in the periphery of the six insulated wires **110a** as an external layer. An intervening substance such as aramid fiber or spun rayon yarn may be provided in a gap between the insulated wires **110**.

It is preferable to twist the insulated wires **110**. In this case, all the insulated wires **110** may be collectively twisted, or the insulated wires **110** may be twisted every insulated wires **110a** of the internal layer and insulated wires **110b** of the external layer. In the case of being collectively twisted, a relative position of the insulated wires of the internal layer used as a ground wire and the insulated wires **110b** of the external layer used as a signal wire can be maintained constant along the length direction of the multi-core cable **101**. Accordingly, a positional relationship between the insulated wires **110a**, **110b** in a cross section perpendicular to the axis of the multi-core cable **101** can be similar in any cross section. A filler may be provided at the center (in FIG. 5, a region surrounded by the six insulated wires **110a**) of the insulated wires **110a** of the internal layer.

The wrapping **120** is wound on the periphery of the plural insulated wires **110** (**110a**, **110b**) arranged in this manner and thereby, the insulated wires **110** are bundled without destroying its positional relationship. The wrapping **120** is formed by wrapping, for example, a resin tape made of polyester on the periphery of the insulated wires **110**.

The periphery of the insulated wires **110** is covered with the overall shield layer **130** through the wrapping **120**. The overall shield layer **130** is formed by spirally winding, for example, plural tin-plated copper wires with a conductor diameter of 0.064 mm on the periphery of the insulated wires **110**.

The outer periphery of this overall shield layer **130** is covered with the sheath **140**. The sheath **140** is formed by wrapping, for example, a resin tape made of polyester on the periphery of the overall shield layer **130**. In the multi-core cable **101** of Embodiment 8 including 72 AWG 47 insulated wires **110**, an outside diameter of the sheath **140** is, for example, 1.19 mm.

The sheath **140** may be obtained by extruding and coating polyvinyl chloride (PVC), polyolefin or fluorine resin, instead of using a resin tape.

As shown in FIG. 6, in the ends of the multi-core cable **101** of Embodiment 8, terminal processing is performed. That is, the sheath **140**, the overall shield layer **130**, the insulated wires **110b** of the external layer and the insulated wires **110a** of the internal layer are sequentially cut with laser processing, thereby exposing the overall shield layer **130**, the insulated wires **110b** of the external layer, the insulated wires **110a** of the internal layer and the central conductors **111** of the insulated wires **110a** from the sheath **140** in a stepwise manner.

Then, the central conductors **111** of the plural insulated wires **110a** of the internal layer are collectively grounded and also, the end of the overall shield layer **130** is grounded. The insulated wires **110a** and the overall shield layer **130** are respectively connected to a ground terminal **24** of a connector etc., as shown in FIGS. 5 and 6, to which the multi-core cable **101** is connected. The insulated wires **110a** and the overall shield layer **130** may be connected to the same terminal, or may be connected to different terminals as shown in FIG. 6.

By performing the above-described terminal processing, since the insulated wires **110a** of the internal layer and the overall shield layer **130** which covers the periphery of the insulated wires **110a** are coaxial, the multi-core cable **101** itself functions as a coaxial cable.

Conductor resistance, insulation resistance and dielectric strength of the multi-core cable **101** were measured.

As a result, the conductor resistance of the multi-core cable **101** was, for example, a maximum of 23000  $\Omega$ /Km, and the insulation resistance was 1524 M $\Omega$ /Km or more, and the dielectric strength was 150 ACV/min. This means that the multi-core cable **101** of Embodiment 8 has sufficiently practicable electrical characteristics.

On the other hand, in a conventional multi-core cable using a coaxial wire as each core wire, the periphery of insulated wires constructed by covering the periphery of a central conductor with an insulating coating must further be coaxially covered with an external conductor and a protective coating, so that an outside diameter of each core wire (coaxial wire) becomes larger than that of the insulated wire **110** by about 0.1 mm. As a result, when the multi-core cable is formed by collecting the plural coaxial wires, an outside diameter of the multi-core cable is also large.

That is, an outside diameter of an outermost sheath of the conventional multi-core cable including the same number (72) of AWG 47 coaxial wires as the number of insulated wires **110** included in the multi-core cable **101** of Embodiment 8 is, for example, 2.3 mm, and is larger than 1.19 mm of the outside diameter of the multi-core cable **101** of Embodiment 8.

The multi-core cable **101** of Embodiment 8 is smaller in diameter than the conventional multi-core cable using the coaxial wire as each core wire. As a result, handleability of the

cable is improved and also, workability in the case of connecting the terminal of the cable to a wiring substrate of a medical device such as an ultrasonograph is improved. Also, a stress for a patient to be treated with an endoscope can be reduced.

Further, the multi-core cable **101** of Embodiment 8 has a pseudo coaxial structure by performing the terminal processing so as to respectively grounding the insulated wires **110a** of the internal layer and the overall shield layer **130** which are coaxial, thereby providing good electrical characteristics for practical use in terms of conductor resistance, insulation resistance, characteristic impedance, capacitance, shielding properties, etc.

Although the plural embodiments are described above, the invention is not limited thereto, and other configurations can be adopted as necessary.

For example, the number of insulated wires **110** (**110a**, **110b**) in the multi-core cable **101** of Embodiment 8 is not limited to the above. The multi-core cable **101** can include the necessary number of insulated wires **110** depending on an application.

Although the number of insulated wires **110a** of the internal layer is six in Embodiment 8, the multi-core cable **101** can have a coaxial shielding structure as long as at least one insulated wire **110** is arranged in an internal layer and it is grounded at the terminal.

In Embodiment 8, the twisted wire obtained by twisting three silver-plated copper alloy wires is used as the central conductor **111** of the insulated wire **110**, but instead of this, a copper alloy wire of a single wire may be used. Also in this case, effect similar to those of Embodiment 8 can be obtained.

In Embodiment 8, as the coating **112** of the insulated wire **110**, the fluorine resin such as the perfluoroalkoxy resin (PFA) is used, but the coating **112** may be a foam, and in order to better improve electrical characteristics, for example, a metal tape may be wound on a surface of the coating **112**, or the surface may be plated with metal.

The invention claimed is:

**1.** A multi-core cable arrangement comprising: a plurality of multi-core cables functioning as plural wire units, each of the multi-core cables comprising: at least one ground wire which is arranged in a center in a cross section perpendicular to a length direction of the cable; plural insulated wires arranged in a periphery of the ground wire; an overall shield layer which covers a periphery of the insulated wires, the overall shield layer and the ground wire being coaxial, and the ground wire and the overall shield layer being connected to a ground terminal of a wiring substrate so that the wiring substrate is connected to the multi-core cable; and a sheath which covers a periphery of the overall shield layer; a second overall shield layer which collectively covers a periphery of the plural wire units; and a second sheath which covers a periphery of the second overall shield layer.

**2.** The multi-core cable of claim **1**, wherein the insulated wires are arranged in plural layers so that each layer is coaxial with the ground wire.

**3.** The multi-core cable of claim **1**, wherein the ground wire is another insulated wire.

**4.** The multi-core cable of claim **3**, wherein at least two of the insulated wires as the ground wires are provided.

**5.** The multi-core cable of claim **1**, wherein the ground wire is a conductor wire; another conductor wire and the insulated wires are arranged in a layer around the ground wire; and the another conductor wire electrically connects the ground wire and the overall shield layer.

**6.** The multi-core cable of claim **1**, wherein: the at least one ground wire comprises a non-conductive filler disposed at the center and a plurality of conductor wires disposed about the non-conductive filler.

**7.** The multi-core cable of claim **6**, further comprising: a conductor configured to electrically connect at least one of the conductor wires and the overall shield layer.

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